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OPTIMIZATION

OF THE

EAR FALLS WATER TREATMENT PLANT

FOR

CONTROL OF TRIHALOMETHANES

SEPTEMBER 1997

Ontario

Ministry of
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and Energy

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EAR FALLS WATER TREATMENT PLANT

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CONTROL OF TRIHALOMETHANES

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Report prepared for:

Standards Development Branch
Ontario Ministry of Environment and Energy

EXECUTIVE SUMMARY

BACKGROUND

The two main objectives of the study are:

1. Improvement of the water treatment plant performance to meet the Ontario Drinking Water Objectives (ODWO) THM guideline of 100 µg/L as an annual quarterly average without compromising disinfection, to aim for a filter effluent turbidity of 0.1 NTU, and to meet the aluminum operational ODWO guideline of 100 µg/L.

2. Sustaining long term performance through skills transfer to plant operating staff and recommendations for plant upgrades where required.

The optimization study was funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities should be capable of producing water that meets the ODWO for THM, and also be capable of improved particle removal and lower aluminum residuals, without requiring costly upgrades.

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics. Trihalomethanes are suspected of increasing the risk of cancer following long term exposure. The Ontario government has lowered the guideline from a maximum acceptable concentration of 350 µg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 µg/L based on a running annual average of four quarterly samples.

The associated treatment parameters of turbidity and aluminum residual were also subject of the optimization effort. The ODWO for turbidity is 1 NTU, but current research now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. To reduce potential for disease outbreaks, this study will evaluate the feasibility to obtain a turbidity of 0.1 NTU in the filter effluent. The ODWO operational guideline (not health related) for aluminum in drinking water is 100 µg /L.

The optimization of a water treatment plant consists of evaluating the existing treatment units, conducting laboratory testing to determine the best choice and dosage of the treatment chemicals and implementing changes to the plant operation.

EXISTING CONDITIONS

The Ear Falls Water Treatment Plant was built in 1976. The plant is operated by the Ontario Clean Water Agency (OCWA) for the Township of Ear Falls. The source of the raw water is the English River connecting to Lac Seul. The plant is a conventional configuration using two upflow solids contact type clarifiers with integral flocculation zones and two Ecodyne-Graver Monovalve type gravity sand and anthracite filters. Pre-chlorination was performed at the plant before the fall 1995, but was stopped to reduce the level of THM formation and meet the ODWO guideline. Since that time the plant 'post-chlorinates' only.

The raw water characteristics from January 1994 to October 1995 as reported by the Drinking Water Surveillance Program operated by the MOEE are described as follows:

Colour: 35 to 55 TCU
Turbidity: 2.5 to 13.0 NTU
pH: 7.4 to 7.7
Alkalinity: 35 to 41 mg/L

Plant flows are:

Rated Plant Capacity: 4,545 m^3/d (1 MIGD)
Average Daily Flow: 677 m^3/d (0.15 MIGD)
Max. Daily Flow: 2,085 m^3/d (0.45 MIGD)

PERFORMANCE ASSESSMENT

While the Ear Falls Water Treatment Plant effluent quality is generally well within the MOEE guidelines, there were periods of turbidity and colour excursions. This indicates a tighter control on the process may be warranted. In particular, the operating characteristics of the solids contact clarifier are such that it performs best under steady state conditions with careful control of the sludge blanket level. This type of clarifier is sensitive to upset due to hydraulic surges that occur at start-up, and can lose the sludge blanket suspension that is necessary for effective flocculation when flow is stopped.

CONCLUSIONS

Based on July and August 1996 sampling, the average THM values for the treated water and the distribution system are 80 μg/L and 59 μg/L respectively. The results are in compliance with the ODWO of 100 μg/L for THMs in treated water.

The inactivation of giardia cysts during cold water conditions can not be achieved under existing operational procedures. A free chlorine residual of 1.7 mg/L would be required during the winter and early spring, when the plant is only operated 12 hours per day. Such a high chlorine residual could generate many complaints from the community related to chlorine taste and odour. A high chlorine dosage can also produce THM in excess of the ODWO of 100 μg/L.

If the soda ash injection point for post pH adjustment is relocated to the high lift end of the clearwell and the plant is operated 18 hours per day instead of 12 hours during the winter, the free chlorine residual required would be lower (0.7 mg/L). It is therefore recommended to implement these changes. Relocating the soda ash injection point while maintaining 12 hours of operation would reduce the free chlorine residual required to inactivate cysts to 0.46 mg/L during the summer, reducing further the formation of THM. Higher chlorine levels at the plant may be required to maintain a minimum residual in the distribution system.

The average colour measured during the summer sampling is 36 TCU for the raw water and 4 TCU for the treated water, which is below the ODWO of 5 TCU for the treated water.

The summer sampling showed an average turbidity in the raw water of 6.7 NTU, and an average turbidity in the treated water of 0.32 NTU. The turbidity in the treated water meets the ODWO of 1 NTU. Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada. These protozoan parasites (especially cryptosporidium) are more difficult to kill with disinfectants, and therefore their removal by physical processes is vital. Current US research and experience now indicates that a turbidity of 0.1 NTU in filter effluent is needed to provide protection from cryptosporidium. It is expected that the utilization of PACL as primary coagulant which started in the fall 1996, will help improve the turbidity in the treated water.

The average aluminum residual in the treated water for 1994 and 1995 is 94 µg/L, which is below the Ontario Drinking Water Objective (ODWO) operational guideline of 100 µg/L. The result for April 1995 (221 µg/L), shows that the level of aluminum in the treated water can exceed the ODWO guideline at times. The switch to PACL from alum should result in a lower aluminum residual.

The Ear Falls Water Treatment Plant is a well operated plant. However, from historical records and testing carried out during this optimization study it appeared the plant was subject to periodic excursions in treated water quality. This indicated a loss of process control. In mid-November 1996, OCWA replaced alum with PACL. The results show that the quality of the treated water greatly improved. The turbidity observed in the treated water is less than 0.1 NTU, the colour is close to 0 TCU for a raw water colour between 43 to 80 TCU, and the residual aluminum concentration in the treated water is also reduced. PACL works better under cold water conditions and also provides a wider range of optimum dosage than alum.

RECOMMENDATIONS FOR PLANT SCALE MODIFICATIONS

The Ear Falls Water Treatment Plant is well operated and maintained. The only process modifications recommended are to relocate the soda ash injection point at the high lift end of the clearwell and to extend the operation of the plant to 18 hours per day during the winter, to lower the required free chlorine residual for inactivation of giardia cysts and viruses.

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1.0 BACKGROUND

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics (eg. formed by decay of algae and vegetation) in raw water. Surface water containing high organics also often have high colour levels. The most common forms of trihalomethanes created are chloroform, bromodichloromethane, chlorodibromomethane and bromoform.

The formation of THMs is influenced by several factors:

- Free chlorine concentration - higher Cl_2 = higher THM
- Organic content - higher organic concentration = higher THM
- pH - higher pH = higher THM
- Temperature - higher temperature = higher THM
- Time - normally longer time = higher THM

Since the formation of trihalomethanes is associated with the presence of organics in the water, small inland lakes and rivers, which may contain more organics than large clear bodies of water have a greater trihalomethane formation potential, especially during periods of high runoff.

The reason for adding chlorine to drinking water is to kill bacteria and other microorganisms that cause numerous illnesses. However chlorine use leads to the presence of trihalomethanes and this is a cause for concern; studies have found an association between high levels of trihalomethanes in chlorinated drinking water, and slight increases in cancer following long term exposure of more than 35 years. Chlorine has an advantage over other disinfectants in that it persists many hours or for days and provides protection for the entire water distribution system. The benefit to public health of using chlorine as a disinfectant in drinking water far out-weighs the risk to health associated with the low levels of trihalomethanes created as by-products of chlorination.

In order to decrease the health risk from trihalomethanes, the Canadian and Ontario governments have lowered their respective guideline limits from an "anytime" maximum acceptable concentration of 350 μg/L to an interim maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada and the US. These protozoan parasites (especially cryptosporidium) are more difficult to kill than bacteria with disinfectants, and therefore their removal by physical processes is vital. As a result, Health Canada is now examining the need for stricter standards for particle removal in water plants. The current Ontario Drinking Water Objective (ODWO) for turbidity that applies at the water treatment plant is 1 NTU, but current US research and experience now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. In the attempt to reduce potential for disease outbreaks, this study attempted to evaluate the feasibility to obtain a turbidity of 0.1 NTU in filter effluent.

Alum (aluminum sulphate) is the most widely used coagulant because it is effective, readily available, and relatively inexpensive. However, under some circumstances, or if not used properly, its use can result in elevated levels of residual aluminum in finished drinking water. An article was recently published on facts about human health and aluminum in drinking water (Environmental Science and Engineering Magazine, January 1997). The following is a summary of the major facts presented in the article.

In recent years, increased attention has been focused on possible adverse effects of aluminum in drinking water on human health. Several epidemiological studies have reported a slightly increased incidence of dementia in communities where drinking water is high in aluminum and these studies have raised concerns among the media and public.

A number of theories on the causes of Alzheimer's disease have been proposed and are currently under investigation. From what we know at this time, the evidence linking aluminum and Alzheimer's disease is far from conclusive, but we also cannot be sure that there is no relationship. Humans are constantly being exposed to aluminum via food, air, and water. Ninety percent (90%) of aluminum intake is from food. In general, exposure to aluminum from drinking water is very low (below 3%) compared with that from food and drugs. At the present time the ODWO for aluminum in drinking water is 100 ug/L, which is an operational not health related guideline.

Owners of water treatment plants and water distribution systems who provide water for consumption have legal responsibilities which are shared by all suppliers of food or drink. Owners and suppliers must take reasonable measures to ensure the water is fit for safe consumption.

This optimization study is funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities with a conventional water treatment plant (i.e. coagulation, flocculation, settling, filtration and disinfection) in many cases should be capable of producing water that meets the new THM objective, and also be capable of improved particle removal, without resorting to costly upgrades.

The optimization of a water treatment plant consists of:

- Documentation of existing facility.
- Assessment of the performance of each process unit.
- Verification of the hydraulic loading on each process.
- Laboratory jar testing to determine the best combination of treatment chemicals and the optimum dosages to achieve maximum removal of particulates and dissolved organic material, as well as a minimum level of aluminum residual in the treated water.
- Make required changes to plant operation at full scale to ensure that changes will minimize the formation of THM, but will not compromise the disinfection requirement.

2.0 OBJECTIVES

The two main objectives of the study are:

1. IMPROVEMENT OF EAR FALLS WATER TREATMENT PLANT PERFORMANCE

- Improve plant performance without major capital/equipment expenditures. Specific water quality objectives are listed below in decreasing order of priority:

  A. To comply with the 100 µg/L ODWO for THMs in treated water as a running annual average of four quarterly samples. This objective shall be met while ensuring proper removal and/or inactivation of disease-causing organisms such as bacteria and viruses, since this remains the most critical aspect of drinking water treatment.

  B. To improve particulate removal to reduce or eliminate disease risk from giardia and cryptosporidium. While the ODWO for turbidity is 1.0 NTU, the goal is to achieve 0.1 NTU in the filter effluent.

  C. To keep aluminum residual at or below 100 µg/L to meet the ODWO.

2. SUSTAINING LONG-TERM PERFORMANCE

- Skills transfer to plant operating staff to enable them to effectively control and adjust processes over the long term in response to raw water quality variations.

- Documentation of plant conditions with recommendations for up-grades and operational modifications.

3.0 DOCUMENTATION OF EXISTING CONDITIONS

The Ear Falls Water Treatment Plant was built in 1976. The source of the raw water is the English River connecting to Lac Seul. The plant is a conventional configuration using two upflow solids contact type clarifiers with integral flocculation zones and two Ecodyne-Graver Monovalve type gravity sand and anthracite filters. Pre-chlorination was performed at the plant before the fall 1995, but was stopped to reduce the level of THM formation and meet the ODWO guideline. Since that time the plant 'post-chlorinates' only. The plant is operated by the Ontario Clean Water Agency (OCWA).

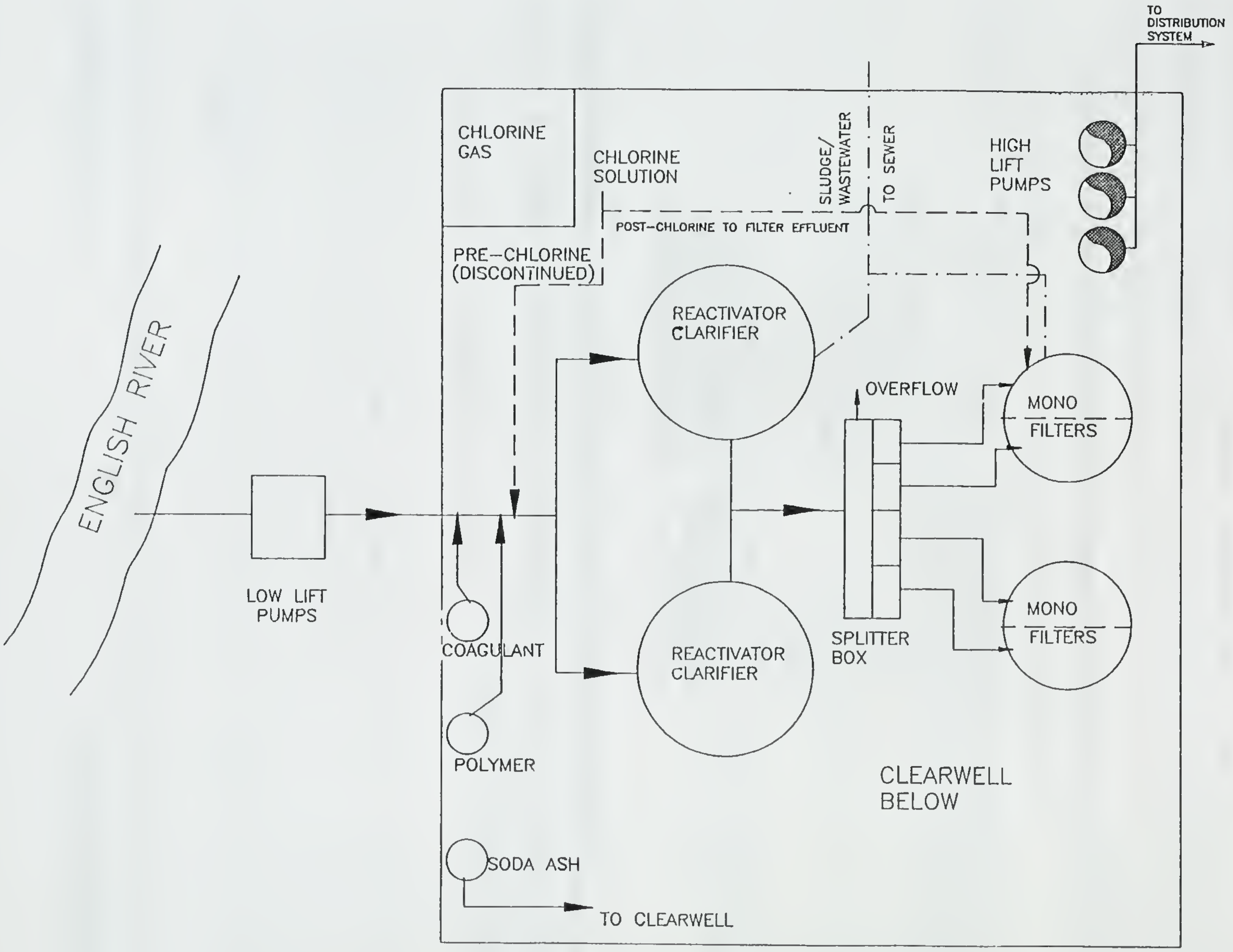
The raw water characteristics from January 1994 to October 1995 as reported by the MOEE's Drinking Water Surveillance Program are described as follows:

Colour: 35 to 55 TCU
Turbidity: 2.5 to 13.0 NTU
pH: 7.4 to 7.7
Alkalinity: 35 to 41 mg/L

Plant flows are:

Rated Plant Capacity: 4,500 m^3/d (1 MIGD)
Average Daily Flow: 677 m^3/d (0.15 MIGD)
Max. Daily Flow: 2,085 m^3/d (0.45 MIGD)

A plant survey was performed during the site visit on June 5, 1996 to prepare a detailed description of existing equipment and condition of operation. The survey is presented in Appendix A, and a flow schematic of the plant in Figure 3.1.



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482 Queen Street, Newmarket, Ontario L3Y 2H4

EAR FALLS
WATER TREATMENT
PLANT
SCHEMATIC

SCALE NTS

FIGURE 3.1

3.1 PROCESS UNITS

In general the treatment plant was operating very well. There were no issues relating to treatment process unit design or operation except for a concern that the filters and the clarifier may foul with the stopping of the pre-chlorination. This was to be monitored and a program of short term intermittent pre-chlorination implemented if a problem was detected. The operating staff have a good understanding of the plant process. A brief description of the process unit operations associated with the plant are:

3.1.1 Low Lift Pumps

Three (3) Crane centrifugal pumps 1,900 L/min (500 USGPM) each.

There were no issues regarding the low lift pumps.

3.1.2 Rapid Mixing

In-line mixer. It is the experience of the plant operators that if the mixer is not cleaned on a regular basis, the degree of mixing and therefore the effectiveness of the coagulant is greatly reduced.

3.1.3 Flocculation/Sedimentation

Number:	2
Type:	Reactivator upflow solids contact
Settling Area:	7.6 m in diameter and 4.4 m in height (25' by 14'-6") each
	3.7 m diameter for the flocculator
	35 m^2 settling area
Upward Rise Rate:	2.7 m/h at rated plant capacity (4,500 m^3/d)

3.1.4 Filtration

Number: 2 filters with 2 compartments each

Type: Ecodyne-Graver rapid gravity filter, dual media (sand/anthracite).
Each unit has a self-storing backwash reservoir.

Dimensions: 3.6 m (12') diameter each

Filter Rate: 9.3 m/h at rated plant capacity (4,500 m^3/d)

3.1.5 Clearwell

Useful volume 482 m^3 (106,000 IG) well baffled reservoir.

Overall dimensions: 24.2 m X 8.2 m X 2.6 m high (79'-4" X 27' X 8'-6" high).

The clearwell is full at 2.45 m.

3.1.6 High Lift Pumps

Three Deming (3) vertical turbine pumps at 1,890 L/min (500 USGPM) each.

There were no issues regarding the high lift pumps.

3.1.7 Standpipe

6,820 m^3 (1.5 MIG)

3.2 CHEMICAL FEED SYSTEMS

The chemical feed systems are:

3.2.1 Alum

Volumetric feeder and transfer pump manually adjusted.

In-line blender injection located on the raw water line.

In November 1996, the plant switched to polyaluminum chloride (PACL) for a full scale trial. OCWA operations report excellent results both in terms of turbidity and colour removal and in filter run and corresponding reduction in backwash water volumes. Testing data was not immediately available.

3.2.2 Polymer

Nalco 8171

W&T Series 44 pump manually adjusted.

Injection point in the pipe just before split.

3.2.3 Soda Ash

Volumetric feeder and transfer pump manually adjusted.

Injection at the entrance of the clearwell.

3.2.4 Chlorine

Chlorine gas.

Dosage point in the clearwell as of October 1995.

The water treatment plant has suspended the pre-chlorinating and is monitoring the clarifier and filter for fouling.

3.3 HISTORICAL DATA

A summary of historical data collected in 1994 and 1995 is presented in Table 3.1. The table summarizes the results of analysis including colour, turbidity, alkalinity, pH, aluminum and THM for the raw and the treated water. The water samples were analyzed for the Drinking Water Surveillance Program (DWSP). The average values for 1994 and 1995 are summarized as follows:

	Raw	**Treated**
• Colour	42 TCU	3 TCU
• Turbidity	7.13 NTU	0.34 NTU
• Alkalinity	39 mg/L-$CaCO_3$	48 mg/L-$CaCO_3$
• pH	7.5	7.3
• Aluminum	132 µg/L	94 µg/L
• THM		120 µg/L

The variation of trihalomethanes in the treated water ranges from 48 to 221 µg/L. The average THM value for 1994 and 1995 (120 µg/L) exceeds the 100 µg/L Ontario Drinking Water Objective (ODWO). The maximum levels observed were for the period of July to October, with values ranging from 87 to 221 µg/L.

The variation of colour in the raw and the treated water for Ear Falls Water Treatment Plant is presented in Figure 3.2. The raw water colour reached a maximum value in July 1995 (55 TCU). The colour for the treated water for 1994 and 1995 ranges from 1.6 to 5 TCU.

The variation of turbidity in the raw and the treated water for 1994 and 1995 is presented in Figure 3.3. The raw water turbidity measured at time of sampling reaches a peak in January and April 1994, with a maximum of 13 NTU. The turbidity for the treated water is moderately low and varies from 0.06 to 1 NTU. Turbidity results are unreliable unless measured at time of sampling.

The average aluminum residual in the treated water for 1994 and 1995 is 94 µg/L, which is below the Ontario Drinking Water Objective (ODWO) operational guideline of 100 µg/L. The result for April 1995 (221 µg/L), shows that the level of aluminum in the treated water can exceed the ODWO guideline at times.

TABLE 3.1 EAR FALLS WATER TREATMENT PLANT
HISTORICAL WATER QUALITY RESULTS
WATER SAMPLES ANALYZED FOR THE DRINKING WATER SURVEILLANCE PROGRAM (DWSP)

	COLOUR (TCU)		TURBIDITY (NTU)*		ALKALINITY (mg/L)		pH*		Aluminum (ug/L)		THM (ug/L)
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Treated
Jan-94	44.4	3.2	13.00	1.00	40.2	42.2	7.35	7.09	190	90	60.5
Apr-94	43	2.6	13.00	—	38.5	44	7.39	7.12	74	53	48.4
Jul-94	40.2	1.6	6.00	0.06	36.8	53.5	7.48	7.25	140	52	220.8
Oct-94	38.2	1.8	8.20	0.09	39.7	41.4	7.67	7.11	182.62	37.88	87.4
Jan-95	35.8	2	4.80	0.24	40.4	49.2	7.6	7.37	131.61	89.37	78.5
Apr-95	40.8	4	2.50	0.60	38.3	58.8	7.5	7.68	75.73	221.32	88.4
Jul-95	55.2	5	4.00	0.14	35.2	42	—	—	130	68	202
Oct-95	36.4	3.2	5.50	0.28	41.2	53.8	7.6	7.18	130	140	173
MINIMUM	35.8	1.6	2.50	0.06	35.2	41.4	7.35	7.09	74	37.88	48.4
MAXIMU	55.2	5	13.00	1.00	41.2	58.8	7.67	7.68	190	221.32	220.8
AVERAG	41.8	2.9	7.13	0.34	38.8	48.1	7.51	7.26	131.75	93.95	119.9

NOTE: *: The results for turbidity and pH come from field analysis.
Results for these parameters are unreliable unless measured at time of sampling.

FIGURE 3.2 EAR FALLS WTP - RAW AND TREATED WATER COLOUR FOR 1994 AND 1995 (DWSP DATA)

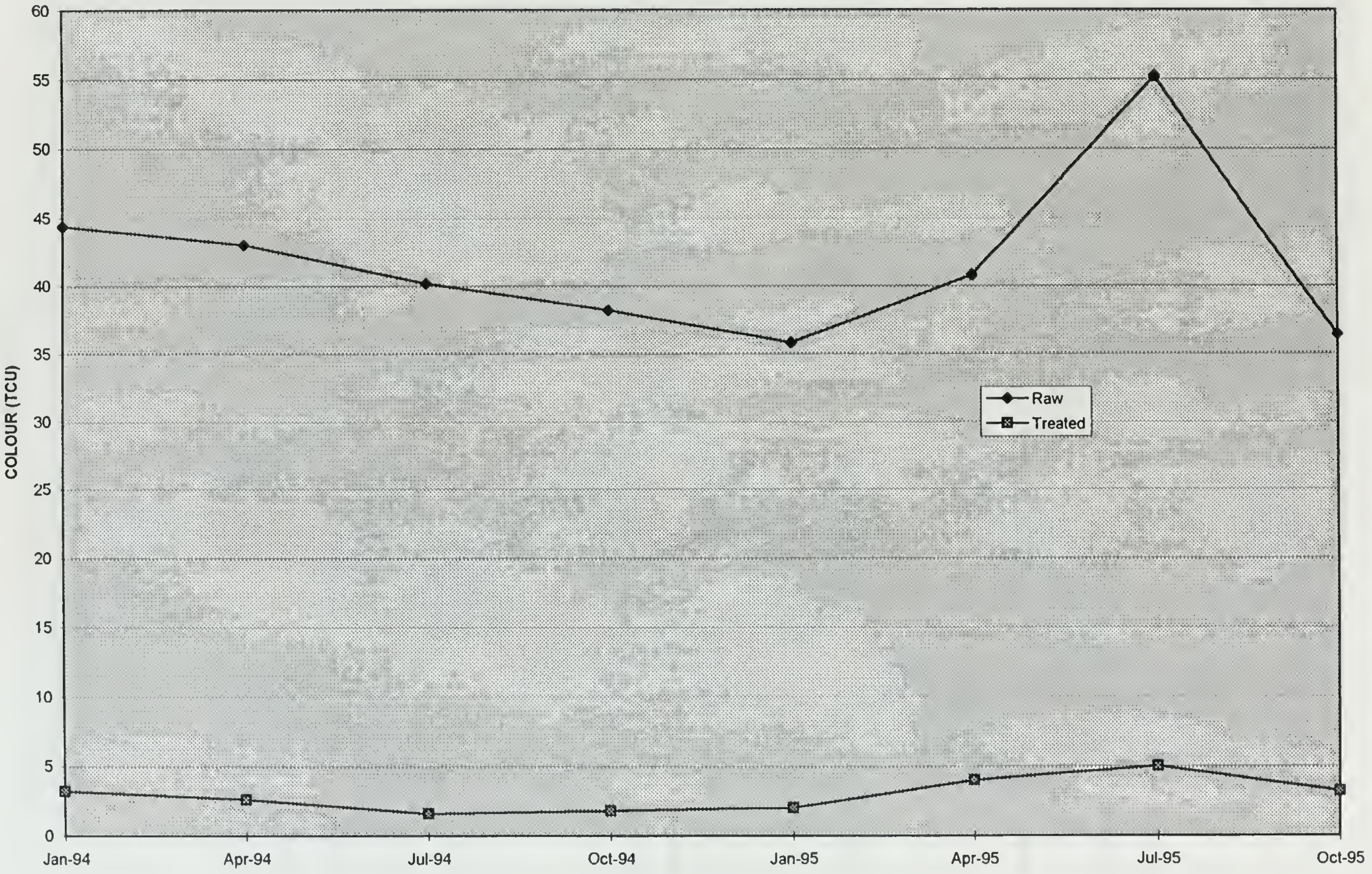
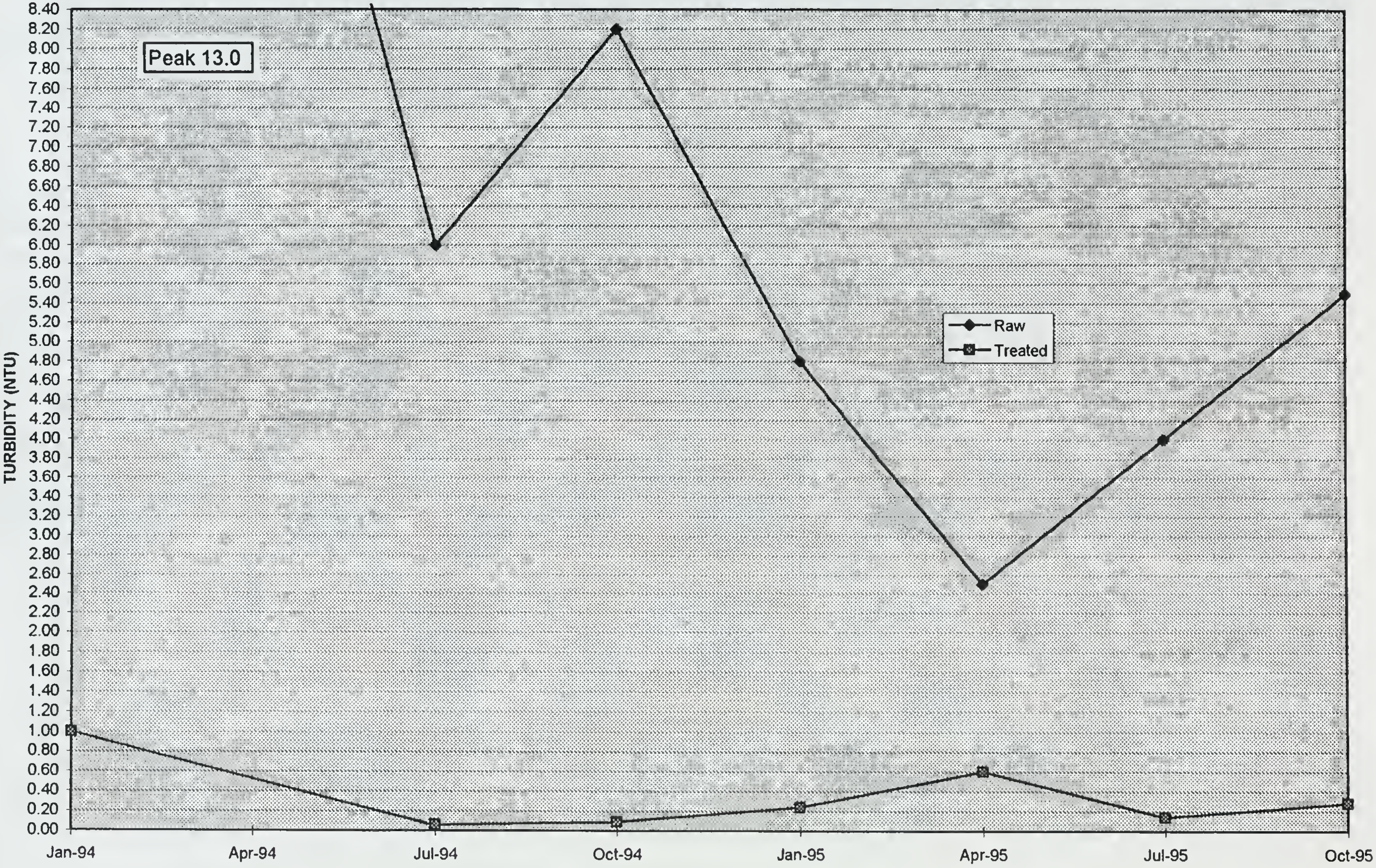


FIGURE 3.3 EAR FALLS WTP-RAW AND TREATED WATER TURBIDITY FOR '94 AND '95 (ON-SITE DWSP DATA)



4.0 PERFORMANCE ASSESSMENT

4.1 JULY AND AUGUST SAMPLING

Additional water samples were collected at the treatment plant in July and August 1996 to establish a baseline for THMs versus the level of colour and Total Organic Carbon (TOC). The samples were analyzed by Novamann. The results obtained from five weeks of sampling are summarized in Table 4.1. The operation data collected for the days of sampling including average daily flow, turbidity, raw water temperature and chemical dosages and residuals are presented in Table 4.2.

4.1.1 Colour

The average colour measured during the summer sampling is 35.6 TCU for the raw water and 4 TCU for the treated water.

The plant is generally performing well although the most recent colour level in the treated water, 18.5 and 44 TCU for October and November, 1996 respectively, indicates that there was a significant problem with the chemical feed. Following this period the plant converted to PACL and returned to or improved on the previous performance.

4.1.2 THM

The OCWA staff implemented a process change in October 1995 when they were made aware of the THM issue, by eliminating the pre-chlorination. It was suggested to the staff that the only consequence of this change may be a tendency for the filters to foul more readily. If this were to occur, periodic shock chlorination could be practiced during the backwash procedure to kill any microbial growth. All backwash wastewater is piped to the sewage treatment lagoons therefore, there is no problem with the discharge of chlorinated washwater to the environment.

Routine measurement of the initial head loss after filter backwash would help to determine when it is time for shock chlorination of the filter. Biological fouling and formation of mud balls in the media will increase the initial filter head loss over time.

The installation of an air scour is another option to be considered, and would involve the replacement of the strainer to allow for air/water wash. However, a telephone conversation on December 13, 1996 with the superintendent indicated that after stopping pre-chlorination for more than one year, no operational problem has been noticed. There is no appearance of mud ball formation in the filter and no reduction of its performance has been recorded. There was no need to do shock chlorination of the filter for the first year.

From Table 4.1, it is noted that the average THM values for the treated water and the distribution system are 80 µg/L and 59 µg/L respectively for the summer 1996. The results are in compliance with the ODWO of 100 µg/L for THMs in treated water.

Based on THM, colour and TOC analysis performed for Ear Falls Water Treatment Plant, there is no evidence of a direct relation between the level of colour or TOC in the water and the level of THM formed. The lack of THM-colour correlation is somewhat unexpected since in general the higher the colour, the higher the organic content, therefore producing higher THMs. In addition to the limited number of samples collected, other factors which may have contributed to the lack of correlation include the narrow range of colour value observed, and the analytical variability for THM analysis. The detection limit of the analytical procedures and the method reference used by Novamann is summarized in Appendix C.

The water samples taken in the distribution system for THM analysis were quenched with sodium thiosulfate to remove any chlorine residual and stop any further reaction between free chlorine and organics. Quenched water samples will maintain the same level of THM as existed at the time of sampling. This is most representative of what people are drinking. The water samples taken at the water treatment plant for THM analysis were not quenched, the reason being to simulate the effect of additional contact time in the distribution system versus the development of THM

Post pH adjustment with soda ash is currently performed at the entrance of the clearwell. The relocation of the soda ash injection point to the high lift end of the clearwell is recommended to improve disinfection (see Section 4.2.3), and potentially reduce THM formation, since THM production increases in proportion to increases in the pH. The dosage of soda ash would be controlled by the high lift pumps operation.

4.1.3 Turbidity

All results presented in this section are from Table 4.2, which contains analytical data collected at the water treatment plant. The variation of the raw water turbidity measured at time of sampling for July and August 1996, ranges from 6.2 to 7.3 NTU. The turbidity for the treated water is moderately low and varies from 0.12 to 0.54 NTU. This is lower than the ODWO of 1 NTU however, it is still higher than the objective of 0.1 NTU which was to be achieved for this study for protection against cryptosporidium.

TABLE 4.1 JULY AND AUGUST SAMPLING FOR EAR FALLS WATER TREATMENT PLANT WATER SAMPLES ANALYZED BY NOVAMANN

PARAMETERS	WEEK 1 (16/07/96)	WEEK 2 (24/07/96)	WEEK 3 (30/07/96)	WEEK 4 (06/08/96)	WEEK 5 (13/08/96)	MINIMUM	MAXIMUM	AVERAGE
Turbidity - Raw Water (NTU)*	3.6	5.2	4.2	5.4	6	3.6	6	4.9
Turbidity - Treated Water (NTU)*	0.5	0.2	0.3	0.8	1.2	0.2	1.2	0.6
Colour - Raw Water (TCU)	42	46.2	42.8	19	28.2	19	46.2	35.6
Colour - Treated Water (TCU)	4	2	2	2.2	8	2	8	4
Colour - Distribution System (TCU)	2	2	1	2.2	6	1	6	3
pH - Raw Water*	7.62	7.94	7.35	7.9	7.84	7.35	7.94	7.73
pH - Treated Water*	9.47	8.02	7.7	8	7.59	7.59	9.47	8.16
Alkalinity - Raw Water (mg/L - CaCO3)	35	30	30	37	30	30	37	32
Alkalinity - Treated Water (mg/L - CaCO3)	134	42	47	57	42	42	134	64
TOC - Raw Water (mg/L)	7.9	7.1	6.1	8	7.1	6.1	8	7.2
TOC - Treated Water (mg/L)	2.6	3.1	1.8	2.8	2.6	1.8	3.1	2.6
TOC - Distribution System (mg/L)	2.8	3	2	2.8	2.7	2.0	3.0	2.7
TTHM - Unquenched Treated Water (ug/L)	140	72	53	73	61	53	140	80
TTHM - Quenched Distribution System (ug/L)	56	62	54	56	68	54	68	59

NOTE *: Results for these parameters are unreliable unless measured at time of sampling.

TABLE 4.2 JULY AND AUGUST SAMPLING FOR EAR FALLS WATER TREATMENT PLANT OPERATION DATA COLLECTED AT THE WTP

PARAMETERS	WEEK 1 (16/07/96)	WEEK 2 (24/07/96)	WEEK 3 (30/07/96)	WEEK 4 (06/08/96)	WEEK 5 (13/08/96)	MINIMUM	MAXIMUM	AVERAGE
Average Daily Flow (m3/d)	873	944	N/A	N/A	N/A	873	944	909
Turbidity - Raw Water (NTU)	6.2	6.7	6.2	7.3	6.9	6.2	7.3	6.7
Turbidity - Treated Water (NTU)	0.53	0.28	0.12	0.14	0.54	0.12	0.54	0.32
Temperature - Raw Water (Degree Celsius)	15	15	18	16	16	15	18	16
Free Chlorine Residual (mg/L)	0.83	0.55	1.24	0.92	1.21	0.55	1.24	0.95
Total Chlorine Residual (mg/L)	N/A	0.6	1.45	1.42	1.77	0.6	1.77	1.31
Alum Dosage (mg/L)	85	102	68	68	100	68	102	85
Polymer 8171 Dosage (mg/L)	0.36	0.25	0.5	0.82	0.47	0.25	0.82	0.48
Soda Ash Dosage (mg/L)	39	68	39	53	44	39	68	49
Chlorine Dosage (mg/L)	2.55	1.68	1.58	N/A	N/A	1.58	2.55	1.94

N/A: Not Available

4.2 MAJOR UNIT PROCESS EVALUATION

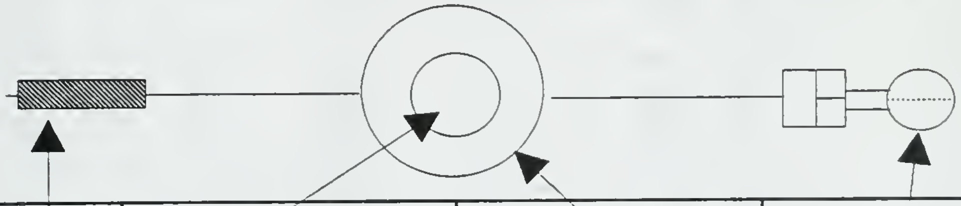
4.2.1 Unit Process Hydraulic Loading

The maximum daily flow (2,085 m^3/d for 1996) is less than half the rated capacity of the treatment process (4,545 m^3/d). However, the plant is operated only 12 hours per day. The equivalent maximum daily flow rate is therefore 2,085 X 24/12 = 4,170 m^3/d. An assessment of the hydraulic loading rate for the actual maximum flow is presented in the following process model.

PROCESS MODEL

Actual Maximum Day Flow	**4,170**	**m3/d**
Flow each train	**2,085**	**m3/d**

ECODYNE PACKAGE PLANT
(TWO EQUAL TREATMENT TRAINS)



MIXING	FLOCCULATOR	CLARIFIER	FILTER
In-line. Details not available.	Diam. 3.7 m Depth 4.4 m Area 10.5 m2 Volume 46.5 m3 MIXER 0.4 kW G 72.7 s-1 Gt 140,066 TIME 32.1 min	Diam. 7.62 m Depth 4.42 m Area 35.1 m2 Volume 155.2 m3 SOR 2.5 m/h TIME 107 min	Diam. 3.66 m Depth 3.20 m Area 10.5 m2 RATE 8.3 m/h

MOEE GUIDELINE

1000 s-1	TIME 30 min Gt 50,000 to 125,000	Max 2.4 m/h	Max 12.0 m/h

Note: Details of in-line mixer and Reactivator to be confirmed

4.2.2 Unit Process Treatment Performance

While the Ear Falls Water Treatment Plant effluent quality is generally well within the MOEE guidelines there were periods of turbidity and colour excursions. This indicates a tighter control on the process may be necessary. In particular, the operating characteristics of the solids contact clarifier are such that it performs best under steady state conditions with careful control of the sludge blanket level. This type of clarifier is sensitive to upset due to hydraulic surges that occur at start-up, and can lose the sludge blanket suspension that is necessary for effective flocculation when flow is stopped even if the mixer remains on.

Recent changes in the primary coagulant from alum to PACL are reported to have improved plant performance and this control issue appears to be resolved at the present time.

4.2.3 Disinfection

Disinfection of drinking water is the most important aspect of the treatment process. Harmful organisms in water such as bacteria, viruses or cysts can cause illness ranging from minor intestinal disorders to potentially fatal infections. Maintaining an effective disinfection system must be the overriding priority of the plant operations. For surface waters, chlorination with a ‘free’ residual is the most common and most practical method of disinfection. To be effective, the treated water must be very low in turbidity as suspended particles can shield bacteria and virus from the effect of chlorine. Even turbidity levels greater than 0.1 NTU can indicate an increased probability of chlorine resistant cysts being present.

To achieve a safe level of disinfection, it is necessary to dose the treated water with a sufficient amount of chlorine to produce a ‘free’ residual, and to give the chlorine sufficient time to inactivate the potentially harmful organisms. This is called the concentration-time factor or CT, also referred to as the primary disinfection stage. Sufficient CT must be achieved at the treatment plant before the first service connection. Current MOEE guidelines call for a minimum residual of 0.5 mg/L for a minimum contact time of 30 minutes after filtration. This disinfection guideline for water treatment plants in Ontario is under review, and the new guideline may be similar to the Surface Water Treatment Rule (SWTR) promulgated by U.S. Environmental Protection Agency (U.S. EPA). The SWTR established CTs value for chlorine, chlorine dioxide, ozone and chloramines required to achieve adequate inactivation of giardia cysts and viruses. For the purpose of calculating CT value, T is the time (in minutes) it takes the water, during peak plant flows, to move between the point of disinfectant application and a point where, C, residual disinfectant (in mg/L) concentration is measured just prior to the first customer. The calculation must take into account the degree of short circuiting in the storage tank.

For free residual chlorination, the CT required is based on the inactivation of giardia cysts in cold water. Cysts are harder to inactivate by free chlorine than viruses, therefore, it is implied that proper inactivation of giardia cysts will ensure inactivation of viruses. Disinfection is not effective for the inactivation of cryptosporidium therefore, it is necessary to perform adequate filtration at the water treatment plant for any municipality at risk of cryptosporidium outbreaks.

Secondary disinfection refers to the maintenance of a residual in the distribution system to protect against bacterial re-growth or minor cross connection contamination. This maintenance residual is commonly achieved with ‘free’ chlorine, but alternatively can be converted to chloramine or ‘combined’ residual with the addition of ammonia. Chloramines have the advantage of being more stable and lasting much longer in the system. They also do not react with organics to form THMs. They are however much less effective as a disinfectant and are very weak in inactivating viruses and cysts. Use of chloramine as a primary disinfectant is therefore not recommended.

The MOEE guidelines recommend a minimum free chlorine residual of 0.2 mg/L at the end of the distribution system. The AWWA recommends a residual of 1.0 mg/L of chloramine be maintained to prevent re-growth (AWWA, 1993). These chlorine residuals do not take into consideration water characteristics such as temperature and pH that affect disinfection efficiency.

According to the SWTR, all community and noncommunity public water systems which use a surface water source or a ground water under the direct influence of a surface water must achieve a minimum of 99.9 percent (3-log) removal and/or inactivation of giardia cysts. According to these guidelines, systems with sewage and agricultural discharges to the source water should provide treatment to achieve an overall 5-log removal/inactivation of giardia cysts, while the minimum required 3-log removal/inactivation is sufficient for sources with no significant microbiological contamination from human activities, a 4-log removal/inactivation of cysts should be provided for source waters whose level of microbiological contamination is between these two extremes.

There are approximately 20 houses, and a fishing and hunting camp using septic systems installed in the proximity of the English River, upstream of the raw water intake. Fecal coliform count is analysed every week for the raw water, and the results always indicated the presence of fecal coliform. There are no agricultural activities surrounding the Ear Falls area. Therefore, due to the potential for microbiological contamination of the raw water, the disinfection requirement will be calculated for a 4-log removal/inactivation of giardia cysts. Well-operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts. The required CT will be based on a 1.5-log inactivation of giardia cysts (4.0 - 2.5-log).

Examples of calculations for CT for winter and summer conditions are presented in Appendix B. The contact time (T) in the clearwell is estimated by using the maximum daily flow for the winter and the summer since it is expected that the peak hourly rate will be provided by the standpipe located in Town. As a conservative approach, T is evaluated under the worst case scenario when the clearwell level is half full.

Based on the "Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Source" (U.S. EPA, 1990), the baffle condition in the clearwell qualified as T_{10}/T factor can be evaluated to estimate the effective contact time in the clearwell. This factor represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mixed chamber.

When tracer studies are not available, a description of the clearwell and baffling condition can be used to estimate the T_{10}/T factor. A schematic of the clearwell is presented on Figure 4.1. Based on the "Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Source", the baffling condition in the clearwell is qualified as above average with a T_{10}/T factor equals to 0.6. An average baffling condition ($T_{10}/T = 0.5$) is described as baffled inlet or outlet with some intra-basin baffles, and a superior baffling condition ($T_{10}/T = 0.7$) is described as perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders. The clearwell for Ear Falls has inlet and outlet baffles as well as intra-basin baffles.

The results of the evaluation of residual chlorine concentration required for inactivation of giardia cysts under various conditions (Appendix B.1 to B.4) are summarized in Table 4.3.

TABLE 4.3 Calculation of minimum residual chlorine concentration necessary for inactivation of giardia cysts

CONDITIONS	FREE RESIDUAL CHLORINE CONCENTRATION (MG/L) C	CONTACT TIME (MINUTES) T
Winter condition when the plant is operated 12 h/d.	1.7	82
Winter condition with post pH adjustment at the end of the clearwell and the plant operated 12 h/d.	1.1	82
Winter condition with post pH adjustment at the end of the clearwell and the plant operated 18 h/d.	0.7	123
Summer condition with post pH adjustment at the end of the clearwell and the plant operated 12 h/d.	0.46	50

Table 4.3 shows that a high free chlorine residual (1.7 mg/L) is required during the winter and early spring when the water temperature is low, under the actual condition when the plant is operated 12 hours per day. Such a high chlorine residual could generate many complaints from the community related to chlorine taste and odour. A high chlorine dosage can also produce THM in excess of the ODWO of 100 µg/L.

CT calculations were also performed for a pH in the clearwell of 6.5, which is the actual pH of the water leaving the filters. A lower pH level is preferable to increase the disinfection performance when using chlorine. The post pH adjustment with soda ash to bring the finished water to pH 7.5 can be performed at the high lift end of the clearwell. Table 4.3 shows that a free chlorine residual of 1.1 mg/L is required during the winter under the actual condition when the plant is operated 12 hours per day, and for a pH in the clearwell of 6.5. This level of free chlorine residual is lower than the free chlorine residual required for a pH 7.5 (1.7 mg/L). However, to reduce the risk of taste and odour and to further reduce the formation of THM, it would be recommended to increase the hours of operation from 12 hours to 18 hours during the winter. If the plant is operated 18 hours per day instead of 12 hours during the winter, the free chlorine residual required is lower (0.7 mg/L). It is therefore recommended to increase the hours of operation to 18 hours per day. This will increase the contact time in the clearwell, thus reducing the free chlorine residual required for proper inactivation of cysts and viruses.

The flow can be reduced by adjusting the throttling valve to lower the low lift pump flow. The maximum day demand during the winter is 1,265 m^3/d. Assuming that 75% of the water demand is over a period of 12 hours (6:00 AM to 6:00 PM), the water demand during that period is 0.75 X 1,265 m^3/d = 950 m^3. The water produced by the treatment plant over that period would be 1,265 m^3/d X 12/18 = 840 m^3. The difference between the water demand and the water produced (950 m^3 - 840 m^3 = 110m^3) can be provided by the water available in the standpipe and the water available in the clearwell. A maximum water volume of 455 m^3 (100,000 IG) can be supplied by the standpipe to maintain a minimum pressure in the distribution system. This represents a water level drop of 3 m (10 ft) from the high water level in the standpipe The water volume available in the clearwell is half of the total volume of the clearwell (1/2 X 482 m^3 = 240 m^3). Therefore, the total volume available in storage is 695 m^3 (455 + 240 m^3), which is greater than the difference between the water demand and the water produced from 6:00 AM to 6:00 PM ($110m^3$). This exercise demonstrates the feasibility to extend the operation of the water treatment plant to 18 hours per day during the winter.

Increasing the hours of operation at the plant during the winter will have no impact on overall chemical consumption since the same amount of water is treated over an 18-hour period instead of a 12-period per day. Therefore, the existing chemical pumps and chemical storage tanks would remain adequate. It is expected that the operation cost for electrical consumption from the low lift pumps would be higher during the winter months when the plant is operated 18 hours per day. There are three low lift pumps available at the plant. The treatment plant is supplied by one pump, the remaining two low lift pumps being in standby. The power requirement for each of the low lift pumps is 11.2 kW (15 HP). The hours of operation will be increased by 6 h/d for a maximum period of six months (180 days). Assuming that the throttled low lift pump will draw 90% of its rated power requirement, and that the cost for electrical energy is $0.09/kWh, the increase in operation costs is estimated to be:

A - B

where,

A = Energy cost when the plant is operated 18 hours per day during the winter

B = Existing energy cost when the plant is operated 12 hours per day during the winter

A = 180 d/year X 18h/d X 0.9 (a throttled pump will draw less power than at full flow) X 11.2 kW X $0.09/kWh
= $2,940

B = 180 d/year X 12 h/d X 1.0 X 11.2 kW X $0.09/kWh
= $2,180

Therefore, the increase in operation costs is estimated to be:

$2,940 - $2,180/year

= $760/year

Information collected from the water plant indicates that a free chlorine residual is normally kept between 0.55 to 1.24 mg/L during the summer, and 0.76 to 1 mg/L during the winter. The actual chlorine dosage performed at the plant during the summer can be reduced by relocating the soda ash injection point at the end of the clearwell and by maintaining a 12-hour operation period during the day. This would reduce the formation of THM. The minimum chlorine dosage required during the summer is also determined by the level required to maintain an adequate chlorine residual at the end of the distribution system.

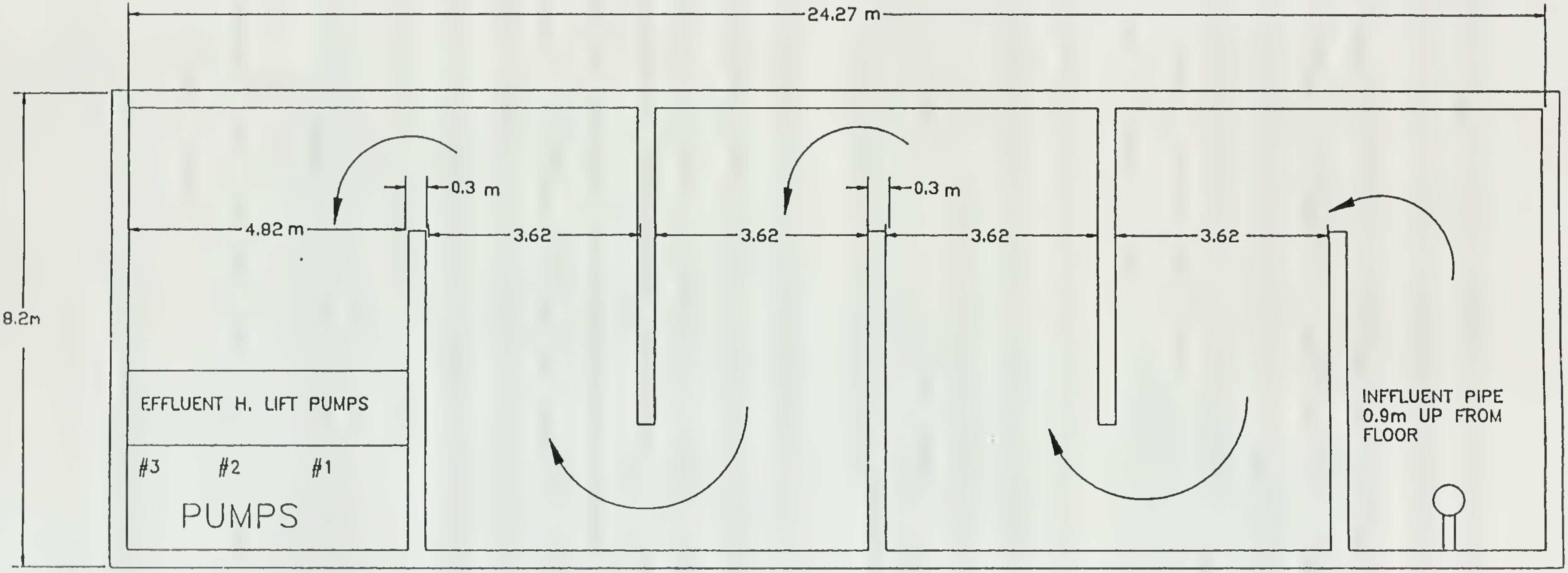


FIGURE 4.1 CLEARWELL LAYOUT FOR EAR FALLS WATER TREATMENT PLANT

5.0 CONCLUSIONS

The THMs in the treated water in July 1994 and 1995 from the DWSP program were 221 µg/L and 202 µg/L respectively. Based on July and August 1996 sampling, the average THM values for the treated water and the distribution system were 80 µg/L and 59 µg/L respectively. The THM level is presently in compliance with the ODWO of 100 µg/L for THMs in treated water taken during the summer when THM formation is the highest.

The inactivation of giardia cysts during cold water can not be achieved under existing operational conditions. A free chlorine residual of 1.7 mg/L would be required during the winter and early spring, under the actual condition where the plant is operated 12 hours per day. Such a high chlorine residual could generate many complaints from the community related to chlorine taste and odour. A high chlorine dosage can also produce THM in excess of the ODWO of 100 µg/L.

If the soda ash injection point for post pH adjustment is relocated at the high end of the clearwell, and the plant is operated 18 hours per day instead of 12 hours during the winter, the free chlorine residual required is lower (0.7 mg/L). It is therefore recommended to relocate the post pH adjustment injection point and to increase the hours of operation to 18 hours per day. Relocating the soda ash injection at the end of the clearwell would also reduce the required free chlorine residual during the summer to 0.46 mg/L, providing there is sufficient chlorine residual at the end of the distribution system. This will further reduce the formation of THM. The increase in energy costs during the winter when the plant is operated 18 h/d is estimated to be $760 /year.

The average colour measured during the summer sampling is 36 TCU for the raw water and 4 TCU for the treated water, which is below the ODWO of 5 TCU for the treated water.

The summer sampling showed an average turbidity in the raw water of 6.7 NTU, and an average turbidity in the treated water of 0.32 NTU. The turbidity in the treated water meets the ODWO of 1 NTU. However, disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada. These protozoan parasites (especially cryptosporidium) are more difficult to kill with disinfectants, and therefore their removal by physical processes is vital. Current US research and experience now indicate that a turbidity of 0.1 NTU in filter effluent is needed to provide protection from cryptosporidium. It is expected that the utilization of PACL as primary coagulant that started in the fall 1996, will help improve the turbidity in the treated water.

The average aluminum residual in the treated water for 1994 and 1995 is 94 µg/L which is below the Ontario Drinking Water Objective (ODWO) operational guideline of 100 µg/L. The result for April 1995 (221 µg/L), indicates that the level of aluminum in the treated water can exceed the ODWO guideline at times. PACL should improve this aspect of treatment.

The Ear Falls Water Treatment Plant is a well operated plant. However, from historical records and testing carried out during this optimization study it appeared the plant was subject to periodic excursions in treated water quality. This indicated a loss of process control. In mid-November 1996, OCWA replaced alum as the primary coagulant to PACL. The results show that the quality of the treated water greatly improved. The turbidity observed in the treated water is less than 0.1 NTU, the colour is close to 0 TCU, and the residual aluminum concentration in the treated water is also reduced. PACL works better under cold water conditions and also provides a wider range of optimum dosage than alum. It is expected that the plant will remain on PACL all year round and that a consistent high quality effluent can be maintained.

Arrangement will be made with Novamann laboratories to provide additional water testing of the raw water (turbidity, colour, pH, alkalinity and TOC), the treated water (turbidity, colour, pH, alkalinity, TOC, THM and aluminum), and the distribution system (colour, TOC and THM) for the next year, to ensure that plant performance is maintained.

6.0 RECOMMENDATIONS

The Ear Falls Water Treatment Plant is well operated and maintained. The only process modification recommended is to relocate the injection point of the post pH adjustment to the end of the clearwell and to extend the operation of the plant to 18 hours per day during the winter, to lower the required free chlorine residual for inactivation of cysts and viruses.

Information collected from the water plant indicates that a free chlorine residual is normally kept between 0.55 to 1.24 mg/L during the summer, and 0.76 to 1 mg/L during the winter. If the soda ash is relocated to the end of the clearwell and the plant is operated 18 hours per day, the free chlorine residual required to provide adequate inactivation of cysts and viruses would be 0.7 mg/L during the winter. Relocating the soda ash injection point and maintaining the plant operation at 12 hours per day would also reduce the required chlorine dosage during the summer to 0.46 mg/L, further reducing the formation of THM. Chlorine residuals at the plant may need to be higher to maintain minimum residuals in the distribution system.

From historical records and testing carried out during this optimization study, it appeared the plant was subject to periodic excursions in treated water quality, indicating a loss of process control. It is recommended that Ear Falls Water Treatment Plant continue to use PACL as primary coagulant instead of alum to improve performance quality for turbidity, colour and residual aluminum concentration in the treated water.

Another option available to help minimize the deterioration of the treated water quality is to run filter to waste at start-up for approximately 15 minutes to minimize plant upsets. Monitoring of the filtered water turbidity would help determine if the filter to waste practice is desirable.

GLOSSARY AND LIST OF ABBREVIATIONS

Alum : aluminum sulphate
CT : Value required to achieve adequate inactivation and/or removal of cysts and viruses. T is the time (in minutes) it takes the water during peak hourly flow, to move between the point of disinfectant and a point where C, the residual disinfectant concentration (mg/L), is measured prior to the first customer.
d : day
°C : degree Celsius
DWSP : Drinking Water Surveillance Program
ECR reagent : Eriochrome Cyanine R
FID : Flame Ionization Detector
ft : foot
G : flocculation energy gradient
Gt : flocculation energy
GC/MS : Gas Chromatograph / Mass Spectrometry
GAC : Granular Activated Carbon
g : gram
h : hour
HFS : hydroxylated ferric sulphate (Ferriclear)
ICP : Inductively Coupled Plasma Atomic Emission Spectoscopy
IG : imperial gallon
kW : kilowatt
L : litre
L/cap.d : litres per capita per day
L/s : litres per second
m : metre
m^2 : square metres
m^3 : cubic metres

m^3/d	: cubic metres per day
m/h	: metres per hour (equivalent $m^3/m^2.h$ - filtration rate)
µg/L	: micrograms per litre
mg/L	: milligrams per litre
mm	: millimetre
mL/min	: millilitres per minute
min	: minute
NTU	: Nephelometric Turbidity Unit
OCWA	: Ontario Clean Water Agency
ODWO	: Ontario Drinking Water Objective
%	: percent
PACL	: polyaluminum chloride
PVC	: polyvinyl chloride
lb	: pound
rpm	: revolution per minute
SOR	: Surface Overflow Rate
SWTR	: Surface Water Treatment Rule
T_{10}/T	: This factor describes the baffling condition in the clearwell, and represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mixed chamber.
TOC	: Total Organic Carbon
THMs	: Trihalomethanes
TCU	: True Colour Unit
W/V	: weight/volume

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Environmental Science and Engineering Magazine. Drinking water Update - The Facts About Human Health and Aluminum in Drinking Water, January, 1997.

U.S. Environmental Protection Agency, Science and Technology Branch Criteria and Standards Division of Drinking Water. Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, October , 1990.

Ontario Ministry of the Environment, Environmental Approvals and Land Use Planning Branch. Guidelines for the Design of Water Treatment Works, April 1982.

APPENDICES

Plant Survey

Appendix A

PLANT **Ear Falls**
Shipping Address: P.O. Box 580, Gold Pine Rd., Ear Falls, Ontario P0V 1T0

Tel: (807) 222-3613 Fax: (807) 222-3031

PREPARED BY: **R.A. LeCraw, P.Eng.**
DATE: Plant Visit June 5, 1996

STAFF:
Superintendent: Larry Benoit
No. of Operators: 2 incl. Super.
Names of Operators:
Miles Brown

Hours of Operation with Staff: 8 h/d, 5 d/week. 4h/d, 2 d/week.
Certified Y/N: Y

PLANT CAPACITY:
Rated Plant Capacity: 4,545 m^3/d (1 MIGD)
Average Daily Flow: 677 m^3/d (0.15 MIGD)
Max. daily Flow: 2,085 m^3/d (0.45 MIGD)

Population Served: 1100 +/-

OPERATING AUTHORITY:
Ontario Clean Water Agency

YEAR OF CONSTRUCTION: 1976

SOURCE OF RAW WATER: English River/Lac Seul

RAW WATER CHARACTERISTICS:
Colour: 35 to 60 TCU
Turbidity: 1.5 to 100 NTU
pH: 7.7 to 7.9
Alkalinity: 35 to 41 mg/L

CHEMICALS:

- Coagulant: Type: Alum, Dry (at time of survey) PACL (changed Nov. 96)
  Dosage: 80 +/- mg/L (Summer), 50 +/- mg/L (Winter)
  Injection Point: In-line mixer raw water line

- Coagulant Aid: Type: Nalco 8171
  Dosage: 0.6 to 0.8 mg/L
  Injection Point: In pipe just before split ahead of Reactivator

- Alkalinity/pH Adjustment: Chemical Used: Soda Ash
  Dosage: 35 mg/L
  Injection Point: Entrance of the clearwell

- Disinfection: Type: Chlorine Gas
  Dosage: 2.4 mg/L (Summer), 1.5 mg/L (Winter)
  Injection Point: Post only, clearwell inlet

ANALYSIS DONE ON-SITE:
Jar Test with water bath for temp. control
Colour Alkalinity
Turbidity
pH

LAB EQUIPMENT AVAILABLE:
Jar Test Equipment
Hach DR 2000
Hach Ratio Turbidimeter
pH meter

PROCESS CONFIGURATION:

CHEMICALS METERING:

	TYPE	CAPACITY	CONTROL	CONDITION
Coagulant:	Dry Alum Volumetric feeder and solution tank		Manual control	Good
Nov/96	PACL		Manual control only	Good
Coagulant Aid:	NALCO 8171 W & T Series 44		Manual control only	Good
• Alkalinity /pH Adjustment:	Soda Ash		Manual control only	Good
• Disinfection:	Chlorine Gas		Manual control only	Good

• Other:

Spare LMI 60 GPD @ 150 psi feed pump and 300 IG +/- poly tank

PROCESS CONFIGURATION (Continued):

INTAKE:	TYPE				CONDITION	NOTES
SCREENING:	TYPE	NO	DIMENSIONS		CONDITION	NOTES
	Auto Backwash Stainer				Good	
LOW LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
	Centrifugal	3		1,890 L/min each	Good	
HIGH LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
	Vertical Turbine	3		1,890 L/min each	Good	
MIXING:	TYPE				CONDITION	NOTES
	In-line mixer					
FLOCCULATION:	TYPE	NO	DIMENSIONS	VOLUME	CONDITION	NOTES
	Reactivator	2	Approx. 3.8 m		Good	
CLARIFICATION:	TYPE	NO	DIMENSIONS	VOLUME	CONDITION	NOTES
	Reactivator	2	7.6 m dia.		Good	
FILTERS:	TYPE	NO	DIMENSIONS	CAPACITY	CONDITION	NOTES
	Monovalve	2 X 2	3.8 m dia.		Good	
CLEARWELL/: ON-SITE RESERVOIR		NO	DIMENSIONS	VOLUME	BAFFLED: Y/N	NOTES
		1	24.2m X 8.2m X 2.6m	482 m^3 (useful volume)	Well baffled	High water level (2.45 m)

PLANT CONTROL:

Flow (Manual Set/Auto): Manually set by low lift pump selection & manual throttling of raw water flow.
Clearwell Level: Level control on low lift pumps from clearwell.

On/Off: Control on plant from Clearwell Level

High Lift Pump Control from Tower

PROCESS MONITORING:

PARAMETERS	INSTRUMENT	MONITORING FREQUENCY	LOCATION	NOTES
• Turbidity:	Lab monitoring (Hach Turbidimeter)	Daily	Raw and filtered	
• pH:	Lab monitoring	Daily	Raw and filtered	
• Free Chlorine Residual:	Lab monitoring	Daily		
• Temperature:		Periodically		
• Aluminum Residual:	MOEE testing only			
• Colour:	Lab monitoring	Daily	Raw and filtered	
• Other:				

ISSUES:

Variable raw water quality. Moderate to high raw water colour (90 TCU+).

Maintenance of a sludge blanket critical to operation of clarifier. If blanket is lost due to malfunction operators increase plant flow and run 24 hours with the clarifier overflowing to waste to speed up the re-establishment of a sludge blanket.

pH monitoring is good but could be installed as a permanent installation with alarms for an early warning on unbalanced process. On-line turbidity monitoring of each filter effluent required.

CHECK LIST:

_ Copy of Certificate of Approval. Required

_ Copy of DWSP report if available. OK

_ Copy of monthly flows for the previous year. OK

_ Copy of the monthly analysis for the previous year to evaluate plant performance for the raw water, settled water and plant effluent. OK

Analysis of interest are: DOC, true colour, turbidity, pH, alkalinity, aluminum residual, chlorine residual, temperature and THM.

Evaluation of Residual Chlorine Concentration for Inactivation of Giardia Cysts

Appendix B

EAR FALLS WATER TREATMENT PLANT

B.1 Evaluation of minimum residual chlorine concentration for inactivation of giardia cysts during the winter for the clearwell 1/2 full and the plant operated 12 hours per day:

NOTES:

- The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve 4-log inactivation of giardia cysts.

- Well operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts.

CT for 1.5-log inactivation = 139 (at 0.5 oC or lower, pH=7.5 and Conc. = 1.7 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell = 482 m3
% Full = 0.5
T10/T = 0.6
Actual Max. Day Flow 1,265 m3/d x 24/12 = 2,530 m3/d
Condition = Winter Time

T = 82 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 1.5-log inactivation / T

CT = 139

C = 1.69 mg/L

EAR FALLS WATER TREATMENT PLANT

B.2 Evaluation of minimum residual chlorine concentration for inactivation of giardia cysts during the winter for the clearwell 1/2 full, post pH adjustment performed at the high lift end of the clearwell and the plant operated 12 hours per day:

NOTES:

* The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve 4-log inactivation of giardia cysts.

* Well operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts.

CT for 1.5-log inactivation = 89 (at 0.5 oC or lower, pH=6.5 and Conc. = 1.1 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell 482 m3
% Full = 0.5
T10/T = 0.6
Actual Max. Day Flow 1,265 m3/d x 24/12 = 2,530 m3/d
Condition = Winter Time

T = 82 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 1.5-log inactivation / T

CT = 89

C = 1.08 mg/L

EAR FALLS WATER TREATMENT PLANT

B.3 Evaluation of minimum residual chlorine concentration for inactivation of giardia cysts during the winter for the clearwell 1/2 full, post pH adjustment performed at the high lift end of the clearwell and the plant operated 18 hours per day:

NOTES:

- The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve 4-log inactivation of giardia cysts.

- Well operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts.

CT for 1.5-log inactivation = 85 (at 0.5 oC or lower, pH=6.5 and Conc. = 0.7 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell 482 m3
% Full = 0.5
T10/T = 0.6
Max. Day Flow = 1,265 m3/d x 24/18 = 1,687 m3/d
Condition = Winter Time

T = 123 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 1.5-log inactivation / T

CT = 85

C = **0.69 mg/L**

EAR FALLS WATER TREATMENT PLANT

B.4 Evaluation of residual chlorine concentration for inactivation of giardia cysts during the summer for the clearwell 1/2 full, post pH adjustment performed at the high lift end of the clearwell and the plant operated 12 hours per day:

NOTES:

* The SWTR establishes CTs for chlorine, chlorine dioxide, ozone and chloramines which will achieve 4-log inactivation of giardia cysts.

* Well operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts.

CT for 1.5-log inactivation = 23 (at 20 oC, pH=6.5 and Conc. = 0.6 mg/L)

Where C = Concentration (mg/L)
T = Contact Time (min)

Evaluation of contact time (T):

T= [Volume of Clearwell (m3) x %Full x Baffling Condition (T10/T)] / [Maximum Day Flow (m3/d)] x 1,440 min/d

Volume of Clearwell	482 m3			
% Full =	0.5			
T10/T =	0.6			
Actual Max. Day Flow	2,085 m3/d	x 24/12 =	4,170 m3/d
Condition =	Summer Time			

T = 50 Minutes

Evaluation of Residual Chlorine Concentration (C):

C = CT for 1.5-log inactivation / T

CT = 23

C = 0.46 mg/L

Analytical Procedures used by Novamann

Appendix C

Detection Limit and Analytical Method Reference used by Novamann

PARAMETERS	**MINIMUM DETECTION LIMIT(MDL)**	**ANALYTICAL METHOD**	**METHOD REFERENCE***
THM	6 μg/L	Purge &Trap GC/MS	EPA 624
TOC	0.1 mg/L	UV/PEROX/FID	EPA 9060
residual aluminum	0.025 mg/L	ICP	EPA 6010
turbidity	0.1 NTU	Turbidity Meter	APHA 2130
true colour	1 TCU	Colourimetric	APHA 2120
pH	0.01	pH Meter	APHA 4500H
alkalinity	1 mg/L - $CaCO_3$	Titration	APHA 2320
ammonia + ammonium	0.05 mg/L	Colourimetric	APHA 4500
anions (NO_3, Cl, SO_4, F)	0.1 to 0.5 mg/L	Ion Chromatography	EPA 300.0
conductivity	1 umho	Conductivity Meter	APHA 2510
lead	0.002 mg/L	Graphite Furnace	EPA 7421
metals		ICP	EPA 6010
nitrite	0.1 mg/L	Colourimetric	APHA 4500
orthophosphate-P	0.005 mg/L	Colourimetric	APHA 4500

Note * : EPA : Environmental Protection Agency
APHA : American Public Health Association